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On the Calculation of Tables of Mortality. By M. A. QUETELET, *Membre de l'Académie Royale de Belgique.* (Translated from the original paper, printed by the Académie Royale de Belgique in t. xix., No. 10, *Des Bulletins.*)

IN order perfectly to obtain its object, a table of mortality must exhibit the *actual* mortality at the different ages; and to be of any practical use, we should be able from the results of the past to predict events for the future.

The actual mortality can only be directly determined by knowing the population, as well as the number of deaths, which occur at each age. There are, however, very few countries in Europe in which these two elements are sufficiently ascertained. Even in Belgium, the division of the population by ages was but imperfectly known till the census of 1846, the results of which were only published about the end of 1848.* It was therefore necessary, in order to form the tables of mortality, to pass over the important element of the existing population, and frame them from the registers of deaths. In this manner, the tables of mortality which I have given successively since 1827 have been constructed on the hypothesis of a stationary population.

It is an error, as I have shown in a former paper (Nov. 8, 1851; *see* t. xviii. *Des Bulletins,* 2^e *partie,* p. 360), to suppose that a table of mortality, computed on the hypothesis of a stationary population, must change to any great extent when the population becomes increasing or decreasing; or, on the other hand, that it remains identically the same whilst the population is stationary. These kinds of questions are extremely difficult, and by their apparent simplicity often lead into error persons unaccustomed to such calculations, as I have observed in another work,† in which I have endeavoured to treat the problem of tables of mortality in its fullest extent.

The interest which attaches to this important subject, and in general to all questions relative to assurances on lives, has induced me to present a summary of the principal results at which I have arrived, in calculating a table of mortality based upon the census of

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* In the census of 1829—which, however, was made with greater exactness than is generally believed—the division of the population by ages was not sufficiently attended to. According to the different periods of life, the population was grouped in totals of five, three, or two years. This subdivision did not allow of supplying with sufficient accuracy the interpolations to correct the errors as to declaration of age which usually occur at the ages expressed in round numbers, such as 30, 40, &c.

† *Le Mémoire sur les Tables de Mortalité,* which will appear in the fifth volume of the *Bulletins de la Commission Centrale de Statistique du Royaume.*

1846, and on the registers of deaths during the decennial period 1841 to 1850.

I commence by giving the general formulæ by which the calculations have been made:—

Let N_0 = the number of births in a year.
N_1 „ of children 1 year of age.
N_2 „ „ 2 years of age.
N_3 „ „ 3 „
. . . .
N_n „ of individuals n years of age.

Let further—

d_0 = the number of deaths from 0 to 1 year of age.
d_1 „ „ 1 „ 2 years of age.
d_2 „ „ 2 „ 3 „
. . . .
d_n „ „ n to $n+1$ years of age.

The numbers N_0, d_0, d_1, d_2, &c., will be given by the registers, and the numbers N_1, N_2, N_3, &c., will be ascertained by the census. This admitted, the mortality of each class will be respectively—

$\frac{d_0}{N_0}$ . . . . 0 to 1 year.
$\frac{d_1}{N_1}$ . . . . 1 „ 2 years.
$\frac{d_2}{N_2}$ . . . . 2 „ 3 „
. . . .
$\frac{d_n}{N_n}$ . . . . n „ $n+1$ years.

Now, if we know the mortality at each age, it will be easy to calculate from year to year the number remaining of the individuals, N_0, born at the same time, supposing it to be admitted that the mortality continues at the same rate: we will call N_1, N_2, N_3, the values of N_0, after 1, 2, 3, &c. &c. years, and we shall have

$N_0-N_1=d_0$ after the 1st year, whence $N_1=N_{01}-d_0$
$N_1-N_2=N_1\frac{d_1}{N_1}$ „ 2nd „ „ $N_2=\frac{N_1}{N_1}(N_1-d_1)$
$N_2-N_3=N_2\frac{d_2}{N_2}$ „ 3rd „ „ $N_3=\frac{N_2}{N_2}(N_2-d_2)$
. . . .
$N_n-N_{n+1}=N_n\frac{d_n}{N_n}$ „ $n+1$ „ „ $N_{n+1}=\frac{N_n}{N_n}(N_n-d_n)$

But the number of births, N_0, must correspond with the successive deaths which will occur every year till all are extinct; and these annual deaths, N_0-N_1, N_1-N_2, N_2-N_3, &c., will be given by the preceding equations: we shall have then

$$N_0=d_0+\frac{N_1}{N_1}d_1+\frac{N_2}{N_2}d_2+\frac{N_3}{N_3}d_3+\text{ \&c.}$$

In the particular case in which

$$\frac{N_1}{N_1}=r^1,\ \frac{N_2}{N_2}=r^2,\ \frac{N_3}{N_3}=r^3,\text{ \&c.,}$$

the population is increasing or decreasing in geometrical progression, and their results

$$N_0=d_0+r^1d_1+r^2d_2+r^3d_3,\text{ \&c.}$$

When

$$\frac{N_1}{N_1}=\frac{N_2}{N_2}=\frac{N_3}{N_3}=\text{ \&c. }=1,$$

the population is stationary, and we obtain

$$N_0=d_0+d_1+d_2+d_3+\text{\&c.}$$

This last hypothesis constitutes that which it has been agreed to call the *method of Halley;* the former, more particularly examined by Euler, has been applied but little in practice. It rarely happens, in fact, as it has been remarked by Moser,* that a population continues uniformly increasing or decreasing during a whole century.

The following comparison comprises three tables of mortality; one calculated directly by the general formula, from the combined data of the census of 1846 and of the registers of deaths from 1841 to 1850; a second, which I computed in 1850, on the hypothesis of a stationary population; and a third (for which I am indebted to M. Liagre), calculated on the hypothesis of a population increasing geometrically in the ratio of 1·0062, and according to the deaths from 1841 to 1850. (*See* p. 30.)

We see that the table computed on the hypothesis of a stationary population gives for infancy a rate of mortality much more rapid than the other two tables. The correspondence of the two last, for the different ages, seems to prove that the population has been steadily increasing in geometrical progression since the beginning of the century.

In other respects the three tables correspond very closely after

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* *Die Gesetze der Lebensdauer.* Berlin, 1839. 1 vol. 8vo.

20 years of age, as may be better seen by assuming unity as the number surviving to age 50, as has been done by Demonferrand in France, and by Galloway in England.

Table of Mortality,
Calculated on the Hypothesis of a Population.

Ages.	By General Formula.	Stationary.	Increasing in Geometrical Progression.
At Birth	10,000	10,000	1,000
1 year	8,497	7,945	850
2 „	7,882	7,123	790
5 „	7,253	6,284	725
10 „	6,886	5,822	685
15 „	6,626	5,555	660
20 „	6,350	5,225	631
25 „	6,036	4,846	595
30 „	5,730	4,539	564
35 „	5,427	4,240	534
40 „	5,110	3,932	501
45 „	4,759	3,592	464
50 „	4,401	3,288	425
55 „	3,968	2,972	383
60 „	3,454	2,616	340
65 „	3,837	2,162	283
70 „	2,161	1,653	218
75 „	1,394	1,098	147
80 „	750	599	82
85 „	312	242	34
90 „	92	68	11
95 „	18	13	3
100 „	2	1	2

Table of Mortality,
Computed on the Hypothesis of a Population.

Ages.	By General Formula.	Stationary.	Increasing.
At Birth	2,267	3,042	2,353
10 years	1,559	1,765	1,612
20 „	1,441	1,589	1,485
30 „	1,300	1,580	1,327
40 „	1,159	1,196	1,179
50 „	1,000	1,000	1,000
60 „	787	796	800
70 „	498	503	513
80 „	175	182	193
90 „	22	21	47

At ages after 50, the two former tables agree better together than with the third, which gives the numbers a little too great; from whence it would appear to result that, previous to the present century, the population was rather stationary than increasing.

S. B.